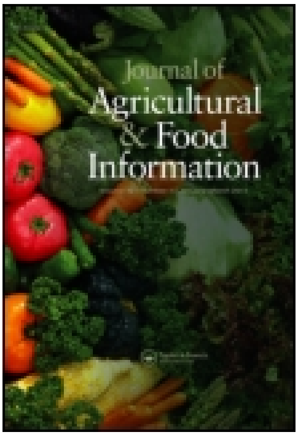


Journal of Agricultural & Food Information
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/wafi20

# Razorbacks: Feral Pigs as Agricultural Pests, Disruptors of Ecosystems, Reservoirs of Contagion, and Favored Game for Sport and Subsistence Hunters: A Review of the Literature, 2005-2011

Tony Stankus [a]
[a] University of Arkansas Libraries, Fayetteville, Arkansas, USA
Published online: 03 Aug 2012.

*Journal of Agricultural & Food Information*, 13:283–301, 2012

ISSN: 1049-6505 print / 1540-4722 online
DOI: 10.1080/10496505.2012.694270



# Razorbacks: Feral Pigs as Agricultural Pests, Disruptors of Ecosystems, Reservoirs of Contagion, and Favored Game for Sport and Subsistence Hunters: A Review of the Literature, 2005–2011

TONY STANKUS

*University of Arkansas Libraries, Fayetteville, Arkansas, USA*

*Whether they are called "razorbacks," as is common in the southern United States (and where they are notably the official sports mascots of the University of Arkansas), or "wild boar," in much of the rest of the world, feral pigs are interbreeding subtypes of Sus scrofa, the same pig domesticated over 5,000 years ago. Once they have become established in the wild, these formerly manageable animals rapidly undergo a dramatic reversion to a wild appearance, may display aggression toward humans, engage in agriculturally and ecologically damaging behaviors, and spread diseases to both livestock and humans. They are the targets of many ongoing, increasingly sophisticated, science-based, eradication efforts.*

*KEYTERMS* *feral pigs, invasive species, Sus scrofa, wild boar*

## INTRODUCTION

In 2005, Julia Perez of Michigan State University provided the community of agricultural librarians with an eminently readable overview of feral pigs. Since that time, over 100 new papers on the topic have appeared, many dealing with the same themes she presented, but adding new case studies of damage caused by feral pigs or reporting new advances in their control. This article is intended to follow in the spirit of her work through a

Received 28 October 2011; accepted 15 December 2011.
Address correspondence to Tony Stankus, University of Arkansas Libraries, MULN 223 E, 365 North McIlroy Avenue, Fayetteville AR 72701-4001, USA. E-mail: tstankus@uark.edu

judicious selection drawn from papers identified via searches in CABI and AGRICOLA.

For those who have not read the original Perez paper, the following feral pig basics may prove useful, before going on to this update:

- Feral pig populations in the United States today are overwhelmingly composed of escaped domestic pigs which assume, sometimes in only a matter of months, the atavistic physical characteristics of never-domesticated wild boars once they are free. These often include a stiff, bristle-studded coat which may include a ridge of particularly sharp spikey hairs that raise up along the spine when the hog is enraged (ergo, "razorback"), as well as a more powerful, highly muscular carcass, an overall elongation of body features—especially the head and snout—with concomitant eruption of sharp, prominent tusks, particularly in the males. Like domesticated pigs, they are rarely active during hot daylight hours but, unlike them, they are often highly mobile at dawn, twilight, and even nighttime, actively ranging very widely in search of food.
- While feral pigs seem to prefer forests with many acorns or tree nuts on which they avidly feed, they routinely invade farmlands, where they will break through fences, devour almost any field crops, even seedlings on tree farms, and cause major property destruction through both trampling ground cover and gouging out (rooting) deep pits and troughs in the search for edible tubers and grubs, on which they also feast. They steal farm animal feed, depriving livestock of their rations. While primarily herbivores, they will eat the eggs of free-range poultry, pursue and may eat live the newborns of any farm animals that cross their paths and cannot outrun them. To their credit, perhaps, they readily eat many agricultural wastes and devour dead farm animals so completely that even skeletal remains cannot be found. While the detrimental effects of feral pigs to agriculture in the United States nationally cause damage in the range of 1.5–2 billion dollars annually, farming in feral pig areas generally continues, if less profitably. By contrast, damage caused by feral pigs in parts of Australia and some Asian Pacific islands is often so catastrophic that, barring successful intensive extermination campaigns, farms have had to be abandoned owing to massive soil erosion and desertification.
- Feral pig populations provide a reservoir of many diseases to which they have developed some immunity but which can be transferred to domestic pigs, other livestock, and even humans. Among the animal-to-animal diseases mentioned by Perez include parvovirus, enterovirus, pseudorabies virus, lice, and internal, generally worm-like parasites. Three serious diseases with particular potential for human infection listed were meliodosis, brucellosis, and leptospirosis.

## RANGE EXPANSION, POPULATION ESTIMATES, AND ANCESTRY OF TODAY'S FERAL PIG COLONIES

One of the most significant developments reported since Perez (2005) has been the range expansion of feral pigs within the United States from about 23 states to 40 (Kaller & Reed, 2010). Most notably, feral pig populations have now firmly taken hold in many northern states, previously thought to be too cold for them, and have also colonized large city parks in cities like Dallas and New Orleans, where they have apparently lost much of their fear of close proximity to humans. Killian, Doten, Rhyan, and Miller (2006) offer an estimate of 3 million feral pigs in the United States, up 1 million from prior published estimates and despite eradication efforts. The Invasive Animals Cooperative Research Centre (2011) of Australia, the country with arguably the world's worst feral pig problems, gives a low population estimate of 3.5 million, spread over 38% of the country's landmass.

However, there is no one best way for estimating populations and figures vary significantly by method chosen. Hone (2008) suggests that, despite the seeming certainty with which population figures are reported, estimation based on aerial surveillance—one of the most commonly used methods—remains problematic because of differing rules for calculation and different guidelines to account for margin of error. A study at a large military base in the United States reported that Global Positioning Satellite data combined with mark-recapture and camera traps (Sparklin, Jolley, Ditchkoff, Mitchell, & Hanson, 2009) gives a better estimate than aerial surveillance alone and discloses much more information on the size of the home range and territoriality of sounders (groups of related sows and their litters), the most important social unit of feral pig life. Bengsen, Leung, Lapidge, and Gordon (2011) suggest that camera-capture methods are preferable for taking a census in dense jungle and rainforest areas and tested their assertion by actually trapping and removing about half the known feral pigs in an area. They found a corresponding, proportional decline in the number of photos triggered of feral pigs in the time that followed in the target area.

Reports based on microsatellite analysis of feral pig DNA, as compared to that of current domesticated pig stocks (e.g., Hampton et al., 2004; Spencer, Lapidge, Hampton, & Pluske, 2005), continue to confirm that the bulk of the burgeoning feral pig populations are, in fact, descended from accidentally escaped domestic stock. Genetic analysis of New Zealand' s feral pig population disclosed that, despite its closer proximity to Chinese, Oceanic, and New World sources of domesticated pigs, the ultimate and virtually sole source of the country's wild boars were escapees from imported stock brought in by British settlers in the early 1800s (Bin et al., 2005).

Deliberate and sometimes illegal releases of pigs, with the goal of their reversion to wild boar form for the purposes of sport hunting, appear to be a relatively minor contributor to current population growth rates, and inheritable biomarkers suggest that the feral pigs resulting from more recent releases remain genetically closer to their fellow modern escapees, rather than to any long-established, isolated wild boars, although some interbreeding can be expected (Spencer & Hampton, 2005).

## FERAL PIG FECUNDITY

Feral pigs can have three litters a year, a rather remarkable rate for reproduction. Costa, Macedo, Santos, Paula, and Faria (2011) explain yet another reason why this is possible. Histological tests of wild board testicles have disclosed exceptionally high sperm-generating capacity tissues within them, comparable to domesticated boars specially maintained for breeding purposes. Likewise, an analysis by Servanty et al. (2011) discloses that, when feral pigs are under heavy hunting pressure, they seem to be able to somehow shorten the reproductive timespan required to fully reconstitute another generation: from 3.6 years down to 2.3. This is a confirmation of earlier seemingly surprising studies by Hanson et al. (2008, 2009). Furthermore, feral pig sows increase their “promiscuity” at time of heavy eradication pressure, coupling with any, and often multiple, boars as are available; a result confirmed by analyzing the paternity concordance of multi-piglet litters (Delgado-Acevedo et al., 2010; Spencer et al., 2005). Finally, intensive eradication efforts may have the unintended adverse effect of selecting for subpopulations within the feral pig community that have evolved not only higher reproduction capacity, but genetically-based resistance or evasion capabilities with respect to poisoning, trapping, or being hunted (Cowled, Spencer, Hampton, & Lapidge, 2006).

## FERAL PIGS, SOIL DISTURBANCE, AND CROP LOSSES

Documenting the degree of damage done by feral pigs often seems like a contest of scientific “one-upsmanship,” because the vast majority of reports of detrimental behaviors seem to go from bad to worse. Dunkell, Bruland, Evensen, and Litton (2011) have demonstrated, through the monitoring of seven pairs of matching watershed land plots (one in each pair with fencing barring feral pigs, one without), that total suspended solids in runoff from naturally occurring storm events in Hawaii were consistently greater in tracts where pigs were able to root and trample, clearly an undesirable result indicating greater soil erosion. However, in another exclusion-by-fence study, Doup, Davis, Lymbery, Mitchell, and Knott (2010) showed that, while feral pig foraging in wetlands and temporary lagoons contributed to water turbidity and anoxia, other non-pig related factors such as ambient temperatures, floods, and amount of rainfall had even greater deleterious impacts, even in areas that were well fenced-in.

Feral pigs are not without their defenders, in specific instances in which they might not be the actual culprits for observed damage or when that damage might not, in fact, be without some potential pig-produced offsets, although that latter point has not recently received much support. For example, the hypothesis that feral pigs may be able to offset the damage they inflict on pastureland by consuming large numbers of grass-eating grubs turns out to be well short of the mark (Hone, 2006). Likewise, soil fertilization through feral pig droppings is not, of itself, a sufficient offset to their rooting behaviors, with fencing still strongly recommended to aid in restoration of native Hawaiian rainforests, so as to allow the normal, undisturbed rotting of fallen logs as the ideal source of natural fertilization in these settings (Mueller-Dombois, 2005).

However, feral pig defecation is at least a partial offset to predation on their favorite foods: acorns, nuts, and seeds dropped from mature trees. Feral pigs have a demonstrated record of dispersing and effectively planting undigested seeds through defecation in locations away from the source of the seeds, thereby spreading overall tree distribution, even if they undercut successional regeneration in locales already rich in mature trees (Webber, Norton, & Woodrow, 2010). However, it also appears from another Australian study by Bloomfield and McPhee (2006) that feral pigs also propagate the wider distribution of weeds through defecation of undigested weed seeds in fields under cultivation. Feral pigs have been disproportionately blamed for retarding tree seedling and understory plant regrowth in some studies but, in a partial vindication, red deer were found instead to be the primary culprit in a notable New Zealand forest preserve (Wilson, Ruscoe, Burrows, McElrea, & Choquenot, 2006). On a number of mid-Pacific islands, feral pigs (and invasive deer) are decimating the population of a traditional food source, the breadfruit tree (Wiles, 2005).

Ultimately, environmental opinion remains heavily weighted against feral pigs. While the detrimental effects of feral pig rooting and trampling in the coastal grasslands of northern California were less severe on some categories of plant (including some invasive perennial grasses that provided good, soil-retaining groundcover), the consensus still suggests that eliminating or reducing feral pig populations is better for both native plant life and soil retention (Cushman, Tierney, & Hinds, 2004; Tierney & Cushman, 2006). Extermination or exclusion is constantly being advised. Reidy, Hewitt and Campbell (2008) have suggested that, at least for the protection of high value crops in Texas, the use of three-strand electrified fences is markedly cost-effective.

## VIRAL DISEASES

In general, feral pigs have a high propensity to transmit viral diseases to domesticated stock in places where both wild and managed pigs share the same areas for drinking water, defecation, and urination (Hampton et al., 2004). Baker, O'Neil, Gramer, and Dee (2011) studied diseases that are well tolerated by feral pigs but still readily transmissible to domestic hogs with sometimes drastic results: porcine circovirous type 2 and swine influenza, the latter being the subject of an intensive review by Penrith, Vosloo, and Mather (2011). Porcine circovirus has also been reported to be endemic among Transylvanian wild boar populations (Cadar et al., 2010).

Pseudorabies virus (also known as Aujesky's Disease) has largely been wiped out in herds of domesticated swine (Müller et al., 2011), but its mode of transmission from wild pigs to farmed animals has not until recently been well understood. Owing to a detailed pathological analysis of multiple samples from infected feral pigs (Hahn, Fadl-Alla, & Lichtensteiger, 2010), it can now be clearly demonstrated that feral pigs seem to concentrate the virus in their mouth, salivary glands, tonsils, taste buds, and even in proximity to their tusks. This suggests that pig-to-pig transmission—whether in the context of fence-to-fence, face-to-face encounters, or outright break-ins into feed and water troughs—is the most likely potential mode of infection.

Cowled and Garner (2008) argue that the best way to track the potential spread of foot-and-mouth disease involves holistic geospatial analysis, into which more than just traditional variables like percentages of infected feral animals and livestock are entered and which shows that it is highly unlikely that any disease spread will be as linear, predictable, and devastating as traditional models of closed-community diseases predict. The best simulations of a feral-pig-induced outbreak of hoof-and-mouth disease in Queensland, Australia, for example, suggest that the weather and local conditions on the ground could play a highly significant role, drastically limiting the spread of the disease in one district, while leaving it unchecked in another (Doran & Laffan, 2005). Ward, Highfield, and Laffan (2009) replicated the study in Texas, adding in a comparison of the traceability of the movements of white tail deer, another foot-and-mouth disease carrier, and finding that feral pigs were notably less predictable in where they were going to be at any given time of day, adding uncertainty about where hotspots of disease might pop up.

West Nile virus has been found in 22% of the feral pigs sampled in Florida, Georgia, and Texas (Gibbs et al., 2006). In effect, mosquitos can potentially bite these infected hogs, which themselves do not appear much ill-affected by housing the virus, and subsequently transfer the virus to humans. The authors suggest that, through monitoring feral pigs and taking blood samples, epidemiologists can get a handle on whether West Nile virus is becoming more or less prevalent in a region and whether or not feral pigs ought to be specially targeted if they have especially high concentrations of the virus. However, contrary to popular belief, the animal virus-incubating hosts for mosquito-to-human transmission of JEV (Japanese Encephalitis Virus) in Australia and surrounding island states are overwhelmingly marsupials, not feral pigs (Van den Hurk et al., 2003). Nonetheless, feral pigs are emerging as a real source of hepatitis E in Europe, which, while not a mosquito-borne viral disease, is typically associated with swampy conditions and contaminated water supplies (Pavio, Xiang-Jin, & Renou, 2010).

## BACTERIAL DISEASES

Handling or eating the meat of feral pigs is scarcely the only, or even the predominant way, these animals foment diseases, although these remain important. Eales, Norton, and Ketheesan (2010) documented an outbreak of brucellosis involving 32 humans in Australia, with all but one case attributable to hunting wild boar. Likewise, feral pigs in their traditional U.S. range, the Southeastern states, have shown frequent prior exposure and future potential infectivity for humans for Bartonella, particularly among hunters and processors of wild game (Beard et al., 2011).

Indirect methods of bacterial disease transmission to humans via feral pigs account for more cases than direct contact or consumption. For example, Jay et al. (2007) have documented 205 cases of a particularly virulent strain of *E. coli* infection (with three deaths) traceable to spinach grown and packaged on a California ranch. While cattle likely shared responsibility for fouling the groundwater and soil with which the spinach was in contact, approximately 13% of captured feral pigs from the fields themselves harbored the exact strain of bacterium implicated in the outbreak.

Another indirect path of disease transmission to humans may be through wild-pig versus domesticated pig contact. Dysenteric diseases spread to domesticated pigs by feral pigs, for example, are becoming an increasing concern in Australia (Phillips et al., 2009). Feral pigs have been identified as a spillover host for bovine tuberculosis (TB), in the sense that, while feral pigs do not generally directly infect humans with TB, they house the bacteria long enough to re-infect more common animal sources of subsequent human infection. In New Zealand, this generally means that, even if TB could be somehow eradicated in the much beloved bushtail possum through capture and drug treatment, these animals would likely reacquire it from contact with feral pigs on their return to the wild (Nugent, 2011). Ballesteros et al. (2011) report serious progress in developing TB-vaccine-laced baits with strong acceptance by feral pigs, in an attempt to control the spread of bovine tuberculosis among wildlife. This work has built on earlier efforts by Cowled, Staples, Smith, and Lapidge (2008c). To be fair to the feral pig, studies suggest that wild hogs get TB more often from other wild animals than they do from each other (Nugent, Yockney, & Whitford, 2011), and it is clear from a retrospective analysis of wildlife pathology reports that the presence of TB cases, even in high numbers, among feral pigs does not always trigger a sizeable outbreak among nearby domesticated animals (Corner, 2006). In one of the most unusual back-and-forth exchanges of a pathogen encountered in the literature, it appears that feral pigs and sea lions can give each other cases of salmonella poisoning. Fenwick, Duignan, Nicol, Leyland, and Hunter (2004) suggest that the cycle may initially have begun with human wastes draining into the shorelines and shallow waters along which feral pigs and sea lions both scrounge for marine life for fodder.

A Portuguese study (Vieira Pinto et al., 2011) and a North Carolina study (Thakur, Sandfoss, Kennedy-Stoskopf, & DePerno, 2011) confirmed the presence of salmonella in local populations of feral pigs and noted the more worrisome presence of *Clostridium difficile*, a notoriously drug-resistant bacterium that was studied earlier in feral pigs by Ramlachan, Anderson, Andrews, Laban, and Nisbet (2007). However, claims that all feral pigs everywhere harbor particularly heavy loads of drug-resistant bacteria were proven largely unfounded in a study done in the Panatanal floodplain in Brazil, with the exception of some modest oxacillin resistance detected (Lessa, Paes, Santoro, Mauro, & Vieira-da-Motta, 2011).



## FERAL PIGS AND PARASITES

Wild boar are also vectors of invertebrate internal and external parasites to other animals and to humans. Not too surprisingly, feral pigs often have a heavy load of ticks which transmit a number of viral diseases of the spotted fever type (Li, Fenwick, Abdad, & Adams, 2010). Herrera et al. (2004, 2005) reported that feral pigs in Brazil had a three-fold higher rate of infection with trypanosome parasites than did farmed pigs. However, heavy loads of trypanosome parasites were a common feature of a number of common Brazilian predators, including the coati and ocelot, as well as of at least two types of peccaries (Herrera, Freitas, Jansen, Abreu & Keuroghlian, 2008; Herrera et al., 2011), so that feral pigs alone cannot be solely blamed for transmission of these parasites to other animals or to humans, when vector insects bite a host animal and convey the parasite to a new victim. Sandfoss, DePerno, Patton, Flowers, and Kennedy-Stoskopf (2011) have documented that about a quarter of the feral pigs sampled in a North Carolina study tested positive for exposure to *Toxoplasma gondi*, a parasite often associated in the popular imagination with kitty litter handling, but just as harmful for human pregnancies and neurological health when coming from wild hogs.

## FERAL PIGS AS GAME FOR HUNTERS AND MEAT SOURCE

One of the more upbeat assessments of feral pig introductions comes from Brazil, where, within the confines of a major neotropical wildlife preserve, the massive Pantanal floodplain, indigenous people are allowed to hunt game for subsistence. There, Desbiez, Keuroghlian, Piovezan, and Bodmer (2011) report that feral pigs have actually help spare native wild animals such as the peccary from endangerment through overhunting, by becoming a larger, more worthwhile target for the table. Likewise, Oliveira-Santos, Dorazio, Tomas, Mourão, and Fernandez (2011) found no other ecological niche dislocation of native peccaries caused by invasions of feral pigs there. However, not all aboriginal cultures are as willing to switch their primary protein source. A study by Fordham, Georges, and Brook (2008) showed that, in communities where freshwater turtles were a favored source of food for both humans and feral pigs, there was no such switchover by local hunters from turtles to pigs and that turtle populations would eventually become unsustainable without programs to eradicate feral pigs.

The relative danger to hunters of eating wild boar is a matter of serious contention and differing perspectives. Atanassova, Apelt, Reich, and Klein (2008); Eglezos, Stuttard, Huang, Dykes, and Fegan (2008); Gill (2007); and Membre, Laroche, and Magras (2011) all analyzed the food safety of wild boar meat and all found significant presence of some bacterial pathogens. Despite the fact that wild boar is often field-dressed or processed and aged at ambient temperatures in somewhat primitive settings, if (and only if) thoroughly cooked, it may not be notably more hazardous than domestic pork, with a few exceptions, most notably higher populations of *Trichinella* (Bartuliene, Liausediene, & Motiejuniene, 2009)—a worm-like nematode parasite—once also endemic in domestic pigs. However, Wachek, Fredriksson-Ahomaa, König, Stolle, and Stephan (2010) gave a much more negative estimate of microbiological food safety based on extensive analyses of Swiss boar hunting kills.

Quaresma et al. (2011) reported that a detailed analysis of wild boar meat intended for human consumption uncovered a very healthy lipid profile and exceptional fat-soluble vitamin content. This largely confirmed the results of Skewes, Morales, Mendoza, Smulders, and Paulsen (2009), who compared wild boar meat to that of domestic pigs, with results favorable to the former. Dominik, Salakova, Buchtova, and Steinhauser (2010) analyzed the sensory profile and nutritional content of wild boar meat by age and gender and reported that the best (i.e., most distinct or genuinely characteristic and strong) wild boar flavor and fat profile was actually had from mature males, not sows or younger animals. While wild boar meat is clearly an acquired taste for many, demand for it as a gourmet item is demonstrably growing in countries like Canada (Burn, 2006). Zochowska-Kujawska, Sobczak, and Lachowicz (2009) reported that wild boar was, however, one of the “chewiest” or toughest meats of large game shot by European hunters in the winter (the prime time for hunting there).

Taggart, Reglero, Camarero, and Mateo (2011) advise that wild boar meat tends to have a higher content of heavy metals from the environment than domestic pork does and suggest that tables of maximum frequency or consumption amounts might be compiled to advise consumers and manage potential health risks.

Fisher (2006) analyzed the situation of feral pigs being hunted and eaten by humans in areas where poisoned baits had previously been released. He found that concentrations of one type of poison, diphacinone, are likely to have washed out of swine populations that ate the poison bait but survived despite this, after about four months, and they were therefore safe to eat. However, this advisory was later contradicted, for two reasons, in the case of feral pigs that lived in areas where the same poison was used to kill rats. First, feral pigs routinely not only steal rat baits but eat any dead rats they come across and therefore indirectly ingest poison. Second, since it is common for rat poisoning programs to be continuous, not episodic with a clear endpoint as is the case with many feral pig eradication programs, washout calculations for poison levels will always be uncertain (Pitt, Higashi, & Primus, 2011). Those authors also advise that no amount of cooking seemed to be able to reduce the poison's concentration.



## THE INCREASING COMPLEXITY OF FERAL PIG ERADICATION AND REMOVAL STRATEGIES

Based on an experience in a remote and not-yet-extensively-feral-pig-invaded area of Australia—and suspicious of the efficacy of too-small-conventional-MU (Management Unit)-acreage-based schemes—Cowled et al. (2008b, 2009) advocated a holistic, detailed mapping of multiple sectors within larger regions to identify likely future feral pig hotspots, with special attention to year-round rainfall and temperature patterns, wetlands, favorable ground cover, and the locations of wild and cultivated plants that would come under attack. Nogueira, Silvius, Fragoso, Nogueira-Filho, and Bassford (2007) assert that animal behavior analysis must be added to all of these other considerations, particularly greater exploitation of the feral pig's sense of smell and attraction to pheromones and a better understanding of how they blaze their trails going back and forth to seasonally rich agricultural fields or especially productive growth spurts of edible wild vegetation (Nogueira-Filho, Fragoso, & Nogueira 2009), in order to build more alluring traps and more precisely locate networks of snares. Mitchell, McIlroy, Mayer, and Dorney (2009) confirmed that getting actual geospatial data about home ranges for given populations of feral pigs is essential for successful eradication. In a particular "World Heritage" quality rainforest in Australia, it had been assumed that damage was caused by very wide-ranging sounders, suggesting that tracking these energetic herds and exterminating them on the run over this broad region was the best strategy. Upon investigation, it was found that, in this particular forest, damage was actually caused by widely scattered, isolated sounders with rather small home ranges, so that identifying these pinpoint populations in their hideouts made more sense.

In Hawaii, Barron, Anderson, Parkes, and ‘Ohukani’ohi’a Gon (2011) reported that the greatest success in feral pig extermination was obtained by repeated broad sweeps in well-defined areas by hunters accompanied by hunting dogs, followed by intensive tracking of individual survivors by hunters working alone. Their only frustration was that some feral pigs are smart enough to flee the targeted district just far enough and just long enough to outlast the extermination hunting campaign, and these subsequently recolonize some of the sites. In Texas, Lavelle et al. (2011) demonstrated that extermination involving first chasing or corralling feral swine into simple, easily assembled and later disassembled, inexpensive pig enclosure fences, before subsequent shooting, greatly increased the subsequent successful execution of the highest percentage of targeted hogs in an epidemic preparedness exercise. In California at the Pinnacles National Monument Park, McCann and Garcelon (2008) successfully used a combination of fencing; trapping; poison baits; hunting with and without dogs; and radiotelemetry-collared sows, who unawares led hunters to the last remaining sounders, to eliminate 197 pigs. This last tactic was reminiscent of the use of sows in heat as a lure for diehard boars in a study by McIlroy and Gifford (2005). An extremely efficient extermination campaign at Santa Cruz Island off the coast of California moved its designers (Parkes et al., 2010; Ramsey, Morrison, & Parkes, 2009) to enunciate what will very likely become feral pig removal dogma: use first those methods that teach any surviving pigs the least; so, for example, you remove unsuspecting pigs sooner by blitzkrieg shooting from helicopters, so that you can focus on fewer, if wilier, pigs at the end, using Judas sows.

In Australia, the country with the most active feral pig poisoning program, poison baits laced with PIGOUT® brand sodium fluoracetate (also referred to as “1080” in a series of papers by Twigg, Lowe, & Martin, 2005; Twigg, Lowe, Everett, & Martin, 2006; Twigg, Lowe, Martin, & Everett, 2005) knocked down the population by three quarters over a calendar year, with before and after census estimates based on camera capture and carcass counting (Cowled, Gifford, Smith, Staples, & Lapidge, 2006). However, Cowled, Lapidge, and Elsworth (2008a) later counseled against relying solely on PIGOUT® and sought to develop new poison baits based on two physiological weaknesses of the pig. The one based on sodium nitrite was found to be palatable in baits, to kill more quickly, and to occasion less observable distress or pain in its victims. Campbell and Long (2009) report that field tests in Texas of the strawberry-flavored PIGOUT® poison baits popularly used in Australia for feral pig control found that they were simply too attractive to non-target species to represent an environmentally and politically defensible option in the United States. Massei, Coats, Quy, Storer, and Cowan (2010) may have gotten around part of the problem of poisoned baits being consumed by non-target species by developing what they term a

BOSTM (a **B**oar **O**perated Feeding **S**ys**T**e**M**) that incorporates the feral pig's natural propensity to get doggedly around obstacles to get at food, which, in this case, means lifting covers and poking their snout into spouts to release feed from an assembly built around a self-supporting thick pipe or cylinder that can be set out without the need to monitor it closely. Thus far, few non-target species have been able to activate the bait release and therefore be unintentionally affected. Tetracycline, in sufficient doses, stains the teeth of feral pigs and, when added to poison baits, serves as a fluorescent indicator of whether or not captured pigs have been eating them, with the degree of staining serving as a proxy for how much poison bait has been consumed (Reidy, Campbell, & Hewitt, 2011).

Killian et al. (2006) have conducted a successful "proof of concept" trial in Florida of one-shot injections of immune-contraceptives in feral pigs that have subsequently shown significantly diminished reproductive capabilities. Unfortunately, a promising feral pig oral ovotoxin, ERL-4221, trialed at Texas A&M University-Kingsville, proved to be a failure (Sanders et al., 2011).

Ultimately, Reddiex and Forsyth (2006) said that, until eradication schemes were tested using the equivalent of double-blind methods as seen in clinical medical research, most arguments about the efficacy of given methods or given sequences of methods could neither be proven or disproven.



## CONCLUSIONS

Owing to problems of habitat destruction and the spread of diseases, farmers and environmentalists continue to be locked in a battle for eradication or at least population control of feral pigs, whose only consistent allies have been the much smaller community of sports and subsistence hunters. The increased use of geospatial monitoring, poison bait campaigns, and animal control hunting expeditions, often prompted by reigns of soil-gouging terror, may ultimately tip the balance in favor of humans, but the innate intelligence and reproductive resilience of these razorbacks is likely to sustain widespread research interest and the continued multiplication of feral pig papers, for the foreseeable future.

## REFERENCES

Atanassova, V. V., Apelt, J. J., Reich, F. F., & Klein, G. G. (2008). Microbiological quality of freshly shot game in Germany. *Meat Science*, *78*(4), 414–419.

Baker, S. R., O'Neil, K. M., Gramer, M. R., & Dee, S. A. (2011). Estimates of the seroprevalence of production-limiting diseases in wild pigs. *Veterinary Record*, *168*(21), 564–564.

Ballesteros, C., Vicente, J., Morriss, G., Jockney, I., Rodríguez, O., Gortázar, C., & de la Fuente, J. (2011). Acceptance and palatability for domestic and wildlife hosts of baits designed to deliver a tuberculosis vaccine to wild boar piglets. *Preventive Veterinary Medicine*, *98*(2–3), 198–203.

Barron, M. C., Anderson, D. P., Parkes, J. P., & 'Ohukani'ohi'a Gon, S. M., III. (2011). Evaluation of feral pig control in Hawaiian protected areas using Bayesian catch-effort models. *New Zealand Journal of Ecology*, *35*(2), 182–188.

Bartuliene, A. A., Liausediene, R. R., & Motiejuniene, V. V. (2009). *Trichinellosis* outbreak in Lithuania, Ukmerge region, June 2009. *Eurosurveillance*, *14*(38), 2.

Beard, A. W., Maggi, R. G., Kennedy-Stoskopf, S., Cherry, N. A., Sandfoss, M. R., DePerno, C. S., & Breitschwerdt, E. B. (2011). *Bartonella* spp. in feral pigs, southeastern United States. *Emerging Infectious Diseases*, *17*(5), 893–895.

Bengsen, A. J., Leung, L. K. P., Lapidge, S. J., & Gordon, I. J. (2011). Using a general index approach to analyze camera-trap abundance indices. *Journal of Wildlife Management*, *75*(5), 1222–1227.

Bin, F., Gongora, J., Yizhou, C., Garkavenko, O., Kui, L., & Moran, C. (2005). Population genetic variability and origin of Auckland island feral pigs. *Journal of the Royal Society of New Zealand*, *35*(3), 279–285.

Bloomfield, T., & McPhee, S. (2006). Rabbits, foxes and feral pigs: How do they impact on weeds? *Plant Protection Quarterly*, *21*(4), 148–151.

Burn, D. (2006, March). A cut above. *Food in Canada*, *66*(2), 34–42.

Cadar, D., Cságola, A., Spinu, M., Dán, Á., Ursu, K., Lorincz, M., & Tuboly, T. (2010). Prevalence of porcine circoviruses in Transylvanian wild boars, detected by real-time PCR—Short communication. *Acta Veterinaria Hungarica*, *58*(4), 475–481.

Campbell, T. A., & Long, D. B. (2009). Strawberry-flavored baits for pharmaceutical delivery to feral swine. *Journal of Wildlife Management*, *73*(4), 615–619.

Corner, L. A. L. (2006). The role of wild animal populations in the epidemiology of tuberculosis in domestic animals: How to assess the risk. *Veterinary Microbiology*, *112*(2–4), 303–312.

Costa, D. S., Macedo, D. B., Santos, M. D., Paula, T. A. R., & Faria, F. J. C. (2011). Intrinsic rate of spermatogenesis in free-ranging feral pigs (*Sus scrofa* sp). *Animal Reproduction Science*, *125*(1), 165–169.

Cowled, B., & Garner, G. (2008). A review of geospatial and ecological factors affecting disease spread in wild pigs: Considerations for models of foot-and-mouth disease spread. *Preventive Veterinary Medicine*, *87*(3–4), 197–212.

Cowled, B. D., Giannini, F., Beckett, S. D., Woolnough, A., Barry, S., Randall, L., & Garner, G. (2009). Feral pigs: Predicting future distributions. *Wildlife Research*, *36*(3), 242–251.

Cowled, B. D., Gifford, E., Smith, M., Staples, L., & Lapidge, S. J. (2006). Efficacy of manufactured PIGOUT® baits for localised control of feral pigs in the semiarid Queensland rangelands. *Wildlife Research*, *33*(5), 427–437.

Cowled, B. D., Lapidge, S. J., & Elsworth, P. (2008a). Additional toxins for feral pig (*Sus scrofa*) control: Identifying and testing Achilles' heels. *Wildlife Research*, *35*(7), 651–662.

Cowled, B. D., Moran, C., Lapidge, S. J., Garrett, T., Aldenhoven, J., & Odeh, I. O. A. (2008b). Feral pig population structuring in the rangelands of eastern Australia: Applications for designing adaptive management units. *Conservation Genetics*, *9*(1), 211–224.

Cowled, B. D., Spencer, P. B. S., Hampton, J. O., & Lapidge, S. J. (2006). Measuring the demographic and genetic effects of pest control in a highly persecuted feral pig population. *Journal of Wildlife Management*, *70*(6), 1690–1697.

Cowled, B. D., Staples, L. D., Smith, M. I., & Lapidge, S. J. (2008c). Vaccination of feral pigs (*Sus scrofa*) using iophenoxic acid as a simulated vaccine. *Australian Veterinary Journal*, *86*(1–2), 50–55.

Cushman, J. H., Tierney, T. A., & Hinds, J. M. (2004). Variable effects of feral pig disturbances on native and exotic plants in a California grassland. *Ecological Applications*, *14*(6), 1746–1756.

Delgado-Acevedo, J., Hewitt, D. G., Long, D. B., Campbell, T. A., Zamorano, A., & DeYoung, R. W. (2010). Promiscuous mating in feral pigs (*Sus scrofa*) from Texas, USA. *Wildlife Research*, *37*(7), 539–546.

Desbiez, A. L. J., Keuroghlian, A., Piovezan, U., & Bodmer, R. E. (2011). Invasive species and bushmeat hunting contributing to wildlife conservation: The case of feral pigs in a neotropical wetland. *Oryx*, *45*(1), 78–83.

Dominik, P. P., Salakova, A. A., Buchtova, H. H., & Steinhauser, L. L. (2010). Qualitative characteristics leg of wild boar venison. *Maso*, *21*(Suppl.), 23–24.

Doran, R. J., & Laffan, S. W. (2005). Simulating the spatial dynamics of foot and mouth disease outbreaks in feral pigs and livestock in Queensland, Australia, using a susceptible-infected-recovered cellular automata model. *Preventive Veterinary Medicine*, *70*(1–2), 133–152.

Doup, R. G., Davis, A. M., Lymbery, A. J., Mitchell, J., & Knott, M. J. (2010). Efficacy of exclusion fencing to protect ephemeral floodplain lagoon habitats from feral pigs (*Sus scrofa*). *Wetlands Ecology and Management*, *18*(1), 69–78.

Dunkell, D. O., Bruland, G. L., Evensen, C. I., & Litton, C. M. (2011). Runoff, sediment transport, and effects of feral pig (*Sus scrofa*) exclusion in a forested Hawaiian watershed. *Pacific Science*, *65*(2), 175–194.

Eales, K. M., Norton, R. E., & Ketheesan, N. (2010). Brucellosis in northern Australia. *American Journal of Tropical Medicine and Hygiene*, *83*(4), 876–878.

Eglezos, S., Stuttard, E., Huang, B., Dykes, G. A., & Fegan, N. (2008). A survey of the microbiological quality of feral pig carcasses processed for human consumption in Queensland, Australia. *Foodborne Pathogens and Disease*, *5*(1), 105–109.

Fenwick, S. G., Duignan, P. J., Nicol, C. M., Leyland, M. J., & Hunter, J. E. B. (2004). A comparison of *Salmonella* serotypes isolated from New Zealand sea lions and feral pigs on the Auckland islands by pulsed-field gel electrophoresis. *Journal of Wildlife Diseases*, *40*(3), 566–570.

Fisher, P. (2006). *Persistence of residual diphacinone concentrations in pig tissues following sublethal exposure* (DOC Research and Development Series 249). Wellington, New Zealand: New Zealand Department of Conservation.

Fordham, D. A., Georges, A., & Brook, B. W. (2008). Indigenous harvest, exotic pig predation and local persistence of a long-lived vertebrate: Managing a tropical freshwater turtle for sustainability and conservation. *Journal of Applied Ecology*, *45*(1), 52–62.

Gibbs, S. E. J., Marlenee, N. L., Romines, J., Kavanaugh, D., Corn, J. L., & Stallknecht, D. E. (2006). Antibodies to west Nile virus in feral swine from Florida, Georgia, and Texas, USA. *Vector Borne and Zoonotic Diseases*, *6*(3), 261–265.

Gill, C. O. (2007). Microbiological conditions of meats from large game animals and birds. *Meat Science*, *77*(2), 149–160.

Hahn, E. C., Fadl-Alla, B., & Lichtensteiger, C. A. (2010). Variation of Aujeszky's disease viruses in wild swine in the USA. *Veterinary Microbiology*, *143*(1), 45–51.

Hampton, J. O., Spencer, P. B. S., Alpers, D. L., Twigg, L. E., Woolnough, A. P., & Doust, J. (2004). Molecular techniques, wildlife management and the importance of genetic population structure and dispersal: A case study with feral pigs. *Journal of Applied Ecology*, *41*(4), 735–743.

Hanson, L. B., Sparklin, B. D., Ditchkoff, S. S., Jolley, D. B., Grand, J. B., & Mitchell, M. S. (2008). Change-in-ratio density estimator for feral pigs is less biased than closed mark-recapture estimates. *Wildlife Research*, *35*(7), 695–699.

Hanson, L. B., Sparklin, B. D., Ditchkoff, S. S., Jolley, D. B., Mitchell, M. S., & Grand, J. B. (2009). Effect of experimental manipulation on survival and recruitment of feral pigs. *Wildlife Research*, *36*(3), 185–191.

Herrera, H. M., Dávila, A. M. R., Norek, A., Abreu, U. G., Souza, S. S., D'Andrea, P. S., & Jansen, A. M. (2004). Enzootiology of *Trypanosoma evansi* in Pantanal, Brazil. *Veterinary Parasitology*, *125*(3), 263–275.

Herrera, H. M., Freitas, T. P., Jansen, A. M., Abreu, U. G. P., & Keuroghlian, A. (2008). The role played by sympatric collared peccary (*Tayassu tajacu*), white-lipped peccary (*Tayassu pecari*), and feral pig (*Sus scrofa*) as maintenance hosts for *Trypanosoma evansi* and *Trypanosoma cruzi* in a sylvatic area of Brazil. *Parasitology Research*, *103*(3), 619–624.

Herrera, H. M., Norek, A., Freitas, T. P. T., Rademaker, V., Fernandes, O., & Jansen, A. M. (2005). Domestic and wild mammals infection by *Trypanosoma evansi* in a pristine area of the Brazilian Pantanal region. *Parasitology Research*, *96*(2), 121–126.

Herrera, H. M., Rocha, F. L., Lisboa, C. V., Rademaker, V., Mourão, G. M., & Jansen, A. M. (2011). Food web connections and the transmission cycles of *Trypanosoma cruzi* and *Trypanosoma evansi* (Kinetoplastida, Trypanosomatidae) in the Pantanal region, Brazil. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, *105*(7), 380–387.

Hone, J. (2006). Linking pasture, livestock productivity and vertebrate pest management. *New Zealand Journal of Ecology*, *30*(1), 13–23.

Hone, J. (2008). On bias, precision and accuracy in wildlife aerial surveys. *Wildlife Research*, *35*(4), 253–257.

Invasive Animals Cooperative Research Centre. (2011). *Feral pigs*. Retrieved from http://www.feral.org.au/pest-species/faq/feral-pig-faqs/

Jay, M. T., Cooley, M. J., Carychao, D., Wiscomb, G. W., Sweitzer, R. A., Crawford-Miksza, L., . . . Mandrell, R. E. (2007). *Escherichia coli* O157:H7 in feral swine near spinach fields and cattle, central California coast. *Emerging Infectious Diseases*, *13*(12), 1908–1911.

Kaller, M. D., & Reed, D. (2010). Invasive feral swine in Louisiana. *Louisiana Agriculture*, *53*(4), 16–19.

Killian, G., Doten, H., Rhyan, J., & Miller, L. (2006). Immunocontraception of Florida feral swine with a single-dose GnRH vaccine. *American Journal of Reproductive Immunology*, *55*(5), 378–384.

Lavelle, M. J., Vercauteren, K. C., Hefley, T. J., Phillips, G. E., Hygnstrom, S. E., Long, D. B., ... Campbell, T. A. (2011). Evaluation of fences for containing feral swine under simulated depopulation conditions. *Journal of Wildlife Management*, *75*(5), 1200–1208.

Lessa, S. S., Paes, R. C. S., Santoro, P. N., Mauro, R. A., & Vieira-da-Motta, O. (2011). Identification and antimicrobial resistance of microflora colonizing feral pig (*Sus scrofa*) of Brazilian Pantanal. *Brazilian Journal of Microbiology*, *42*(2), 740–749.

Li, A. Y., Fenwick, S. G., Abdad, M. Y., & Adams, P. J. (2010). High prevalence of *Rickettsia gravesii* sp. nov. in *Amblyomma triguttatum* collected from feral pigs. *Veterinary Microbiology*, *146*(1–2), 59–62.

Massei, G., Coats, J., Quy, R., Storer, K., & Cowan, D. P. (2010). The boar-operated-system: A novel method to deliver baits to wild pigs. *Journal of Wildlife Management*, *74*(2), 333–336.

McCann, B. E., & Garcelon, D. K. (2008). Eradication of feral pigs from Pinnacles National Monument. *Journal of Wildlife Management*, *72*(6), 1287–1295.

McIlroy, J. C., & Gifford, E. J. (2005). Are oestrous feral pigs, *Sus scrofa*, useful as trapping lures?. *Wildlife Research*, *32*(7), 605–608.

Membre, J. M., Laroche, M. M., & Magras, C. C. (2011). Assessment of levels of bacterial contamination of large wild game meat in Europe. *Food Microbiology*, *28*(5), 1072–1079.

Mitchell, J., McIlroy, J., Mayer, R., & Dorney, W. (2009). Migration of feral pigs (*Sus scrofa*) in rainforests of north Queensland: Fact or fiction?. *Wildlife Research*, *36*(2), 110–116.

Mueller-Dombois, D. (2005). A silvicultural approach to restoration of native Hawaiian rainforests. *Lyonia*, *8*(1), 61–65.

Müller, T., Hahn, E. C., Tottewitz, F., Kramer, M., Klupp, B. G., Mettenleiter, T. C., & Freuling, C. (2011). Pseudorabies virus in wild swine: A global perspective. *Archives of Virology*, *156*(10), 1691–1705.

Nogueira, S. S., Silvius, K., Fragoso, J. M. V., Nogueira-Filho, S., & Bassford, M. (2007). Feral pigs in Hawaii: Using behavior and ecology to refine control techniques. *Applied Animal Behaviour Science*, *108*(1–2), 1–11.

Nogueira-Filho, S., Fragoso, J. M. V., & Nogueira, S. S. C. (2009). Ecological impacts of feral pigs in the Hawaiian islands. *Biodiversity and Conservation*, *18*(14), 3677–3683.

Nugent, G. (2011). Maintenance, spillover and spillback transmission of bovine tuberculosis in multi-host wildlife complexes: A New Zealand case study. *Veterinary Microbiology*, *151*(1), 34–42.

Nugent, G., Yockney, I. J., & Whitford, E. J. (2011). Intraspecific transmission of *Mycobacterium bovis* among penned feral pigs in New Zealand. *Journal of Wildlife Diseases*, *47*(2), 364–372.

Oliveira-Santos, L., Dorazio, R. M., Tomas, W. M., Mourão, G., & Fernandez, F. A. S. (2011). No evidence of interference competition among the invasive feral pig and two native peccary species in a neotropical wetland. *Journal of Tropical Ecology*, *27*(5), 557–561.

Parkes, J. P., Ramsey, D. S. L., Macdonald, N., Walker, K., McKnight, S., Cohen, B. S., & Morrison, S. A. (2010). Rapid eradication of feral pigs (*Sus scrofa*) from Santa Cruz Island, California. *Biological Conservation*, *143*(3), 634–641.

Pavio, N. N., Xiang-Jin, M., & Renou, C. C. (2010). Zoonotic hepatitis E: Animal reservoirs and emerging risks. *Veterinary Research*, *41*(6), 20.

Penrith, M. L., Vosloo, W., & Mather, C. (2011). Classical swine fever (hog cholera): Review of aspects relevant to control. *Transboundary and Emerging Diseases*, *58*(3), 187–196.

Perez, J. (2005). Hogs gone wild!. *Journal of Agricultural & Food Information*, *6*(2–3), 161–166.

Phillips, N. D., La, T., Adams, P. J., Harland, B. L., Fenwick, S. G., & Hampson, D. J. (2009). Detection of *Brachyspira hyodysenteriae*, *Lawsonia intracellularis* and *Brachyspira pilosicoli* in feral pigs. *Veterinary Microbiology*, *134*(3–4), 294–299.

Pitt, W. C., Higashi, M., & Primus, T. M. (2011). The effect of cooking on diphacinone residues related to human consumption of feral pig tissues. *Food and Chemical Toxicology*, *49*(9), 2030–2034.

Quaresma, M. G., Alves, S. P., Trigo-Rodrigues, I. I., Pereira-Silva, R. R., Santos, N. N., Lemos, J. C., . . . Bessa, R. J. (2011). Nutritional evaluation of the lipid fraction of feral wild boar (*Sus scrofa scrofa*) meat. *Meat Science*, *89*(4), 457–461.

Ramlachan, N., Anderson, R. C., Andrews, K., Laban, G., & Nisbet, D. J. (2007). Characterization of an antibiotic resistant *Clostridium hathewayi* strain from a continuous-flow exclusion chemostat culture derived from the cecal contents of a feral pig. *Anaerobe*, *13*(3–4), 153–160.

Ramsey, D. S. L., Morrison, S. A., & Parkes, J. (2009). Quantifying eradication success: The removal of feral pigs from Santa Cruz Island, California. *Conservation Biology*, *23*(2), 449–459.

Reddiex, B., & Forsyth, D. M. (2006). Control of pest mammals for biodiversity protection in Australia. II. Reliability of knowledge. *Wildlife Research*, *33*(8), 711–717.

Reidy, M. M., Campbell, T. A., & Hewitt, D. G. (2011). A mark-recapture technique for monitoring feral swine populations. *Rangeland Ecology & Management*, *64*(3), 316–318.

Reidy, M. M., Hewitt, D. G., & Campbell, T. A. (2008). Evaluation of electric fencing to inhibit feral pig movements. *The Journal of Wildlife Management*, *72*(4), 1012–1018.

Sanders, D. L., Xie, F., Mauldin, R. E., Hurley, J. C., Miller, L. A., Garcia, M. R., . . . Campbell, T. A. (2011). Efficacy of ERL-4221 as an ovotoxin for feral pigs (*Sus scrofa*). *Wildlife Research*, *38*(2), 168–172.

Sandfoss, M., DePerno, C., Patton, S., Flowers, J., & Kennedy-Stoskopf, S. (2011). Prevalence of antibody to *Toxoplasma gondii* and *Trichinella* spp. in feral pigs (*Sus scrofa*) of eastern North Carolina. *Journal of Wildlife Diseases*,*47*(2), 338–343.

Servanty, S., Gaillard, J. M., Ronchi, F., Focardi, S., Baubet, É., & Gimenez, O. (2011). Influence of harvesting pressure on demographic tactics: Implications for wildlife management. *Journal of Applied Ecology*, *48*(4), 835–843.

Skewes, O., Morales, R., Mendoza, N., Smulders, F., & Paulsen, P. (2009). Carcass and meat quality traits of wild boar (*Sus scrofa* s. L.) with 2n = 36 karyotype compared to those of phenotypically similar crossbreeds (2n = 37 and 2n = 38) raised under the same farming conditions 2. Fatty acid profile and cholesterol. *Meat Science*, *83*(2), 195–200.

Sparklin, B. D., Jolley, D. B., Ditchkoff, S. S., Mitchell, M. S., & Hanson, L. B. (2009). Territoriality of feral pigs in a highly persecuted population on Fort Benning, Georgia. *Journal of Wildlife Management*, *73*(4), 497–502.

Spencer, P. B. S., & Hampton, J. O. (2005). Illegal translocation and genetic structure of feral pigs in western Australia. *Journal of Wildlife Management*, *69*(1), 377–384.

Spencer, P. B. S., Lapidge, S. J., Hampton, J. O., & Pluske, J. R. (2005). The socio-genetic structure of a controlled feral pig population. *Wildlife Research*, *32*(4), 297–304.

Taggart, M. A., Reglero, M. M., Camarero, P. R., & Mateo, R. R. (2011). Should legislation regarding maximum Pb and Cd levels in human food also cover large game meat? *Environment International*, *37*(1), 18–25.

Thakur, S., Sandfoss, M., Kennedy-Stoskopf, S., & DePerno, C. S. (2011). Detection of *Clostridium difficile* and *Salmonella* in feral swine population in North Carolina. *Journal of Wildlife Diseases*, *47*(3), 774–776.

Tierney, T. A., & Cushman, J. H. (2006). Temporal changes in native and exotic vegetation and soil characteristics following disturbances by feral pigs in a California grassland. *Biological Invasions*, *8*(5), 1073–1089.

Twigg, L. E., Lowe, T., Everett, M., & Martin, G. (2006). Feral pigs in north-western Australia: Population recovery after 1080 baiting and further control. *Wildlife Research*, *33*(5), 417–425.

Twigg, L. E., Lowe, T., & Martin, G. (2005). Sodium fluoroacetate residues and carcass degradation of free-ranging feral pigs poisoned with 1080. *Wildlife Research*, *32*(6), 573–580.

Twigg, L. E., Lowe, T., Martin, G., & Everett, M. (2005). Feral pigs in north-western Australia: Basic biology, bait consumption, and the efficacy of 1080 baits. *Wildlife Research*, *32*(4), 281–296.

Van den Hurk, A. F., Johansen, C. A., Zborowski, P., Paru, R., Foley, P. N., Beebe, N. W., . . . Ritchie, S. A. (2003). Mosquito host-feeding patterns and implications for Japanese encephalitis virus transmission in northern Australia and Papua New Guinea. *Medical and Veterinary Entomology*, *17*(4), 403–411.

Vieira Pinto, M. M., Morais, L. L., Caleja, C. C., Themudo, P. P., Torres, C. C., Igrejas, G. G., . . . Martins, C. (2011). *Salmonella* sp. in game (*Sus scrofa* and *Oryctolagus cuniculus*). *Foodborne Pathogens and Disease*, *8*(6), 739–740.

Wacheck, S. S., Fredriksson-Ahomaa, M. M., König, M. M., Stolle, A. A., & Stephan, R. R. (2010). Wild boars as an important reservoir for foodborne pathogens. *Foodborne Pathogens and Disease*, *7*(3), 307–312.

Ward, M. P., Highfield, L. D., & Laffan, S. W. (2009). Modelling spread of foot-and-mouth disease in wild white-tailed deer and feral pig populations using a geographic-automata model and animal distributions. *Preventive Veterinary Medicine*, *91*(1), 55–63.

Webber, B. L., Norton, B. A., & Woodrow, I. E. (2010). Disturbance affects spatial patterning and stand structure of a tropical rainforest tree. *Austral Ecology*, *35*(4), 423–434.

Wiles, G. J. (2005). Decline of a population of wild seeded breadfruit (*Artocarpus mariannensis*) on Guam, Mariana Islands. *Pacific Science*, *59*(4), 509–522.

Wilson, D. J., Ruscoe, W. A., Burrows, L. E., McElrea, L. M., & Choquenot, D. (2006). An experimental study of the impacts of understorey forest vegetation and herbivory by red deer and rodents on seedling establishment and species composition in Waitutu Forest, New Zealand. *New Zealand Journal of Ecology*, *30*(2), 191–207.

Zochowska-Kujawska, J. J., Sobczak, M. M., & Lachowicz, K. K. (2009). Comparison of the texture, rheological properties and myofibre characteristics of SM (semimembranosus) muscle of selected species of game animals. *Polish Journal of Food and Nutrition Sciences*, *59*(3), 243–246.